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IMPROVEMENT OF SOIL CLIMATE IN ALTAY KRAY

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Soil climatology has been formulated in recent years as a new division of Soviet soil science. It emerged as such because national socialist agriculture demanded it and as a result of the development of agricultural science itself. The creation of ideal growing conditions for planted crops and the attempt to increase their productiveness and resistance require a thorough knowledge of soil and soil climate.

Soil climate is dynamic; its elements are temperature, moisture, and aeration. Soil climate depends not only on atmospheric climate but on the soil itself, on plant and snow cover, topography, and on the effect of agriculture on the soil. The stronger the influence of local conditions and the greater the effect of man on the soil, the less is soil climate related to atmospheric climate. This fact poses great possibilities for controlling soil climate and production targets.

In an article titled "Pochvennaya klimatologiya" (Soil Climatology) published in Pochvovedeniye, No 3, 1946, P. I. Koloskov has stated the essence, scope, and objectives of soil climatology most fully and clearly: "The climate of soil is the aggregate of intrasoil physical phenomena of the annual and daily cycle, which affect the life and productiveness of the soil and are related to external climate, the subsoil, and the effect of man on the soil and its cover."

The development of the theory of soil climatology is intimately connected with practical problems of agriculture. The improvement of soil climate by agricultural engineering methods is one of the important objectives of soil climatology. The methods of achieving this goal are based on the ideas of Dokuchayev, Kostychev, and Vil'yams.

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This article will describe briefly an experiment in improving the climate of the topsoil during the winter in Altay Kray. The experiment was carried on over a period of 5 years, 1941-46, at the Barnaul Agrometeorological Station by the Chair of Soil Science and Climatology of the Altay Agricultural Institute.

At the onset of winter, climatic factors there include heavy frosts, little snow cover, and strong continuing winds. The most important factor affecting soil climate at this time of the year is the snow cover. During the first half of winter, its depth does not exceed 10-15 centimeters (by winter's end, it has reached a depth of 30-40 centimeters), with the result that the earth freezes to a depth of 2 meters. The light snow cover also lies very unevenly and, under the influence of the wind, frequently drifts.

Under these conditions, the temperatures of soils, even over a small area, vary sharply in the course of the winter. The observations made in the course of 5 years showed that minimum soil temperatures at a depth of 3 centimeters (using the apparatus of Nizen'kov) ranged from 5 degrees below zero to 10 degrees below zero when the snow cover varied between 30 and 50 centimeters; that they ranged from 10 to 20 degrees below zero when snow cover varied between 10 and 30 centimeters; and that they ranged from 20 to 32 degrees below zero when there was no snow cover. These figures show that, even where there is a heavy snow cover, the topsoil climate is much more severe than in the European part of the USSR.

This variation in soil climate, caused by the light and uneven snow cover during the first half of the winter, explains the heavy damage suffered by winter crops and perennial grasses and also why the winter damage in Siberia occurs in a mottled, mosaic pattern rather than in a diffused pattern, as it does in the European part of the USSR. The close connection between snow cover and winter crop damage is illustrated by the results of one experiment carried out in Barnaul in 1943. Plants covered with 30-50 centimeters of snow emerged from the winter in good condition, those under 20 centimeters of snow suffered 4 percent damage, those under 15 suffered 14 percent damage, those under 5 suffered 40 percent damage, and those under no snow cover at all suffered almost 100 percent damage.

The substantial damage often inflicted on agriculture by unfavorable soil climatic conditions during the winter made it essential to develop methods of early determination of the degree of damage suffered by plants. Using the soil temperatures observed at a depth of 3 centimeters under varying conditions of snow cover, a table was worked out showing the relationship between these temperatures and minimum air temperatures. Then, knowing the actual depth of snow and the severity of present or anticipated frost in the air, it was possible to establish the minimum temperatures in the soil by using the table. Comparing these readings with the critical temperatures at which plants suffer damage, determined naturally or by freezing them artificially, it was possible to prepare a report on the condition of winter crops. This reporting has been done for several years. Thus, a scientific estimate of the condition of winter crops can be made on the basis of determining the temperature of the topsoil.

The improvement of soil climate is, however, even more important than an estimation of the condition of winter crops. In Altay Kray and in many steppe and forest-steppe regions of West Siberia, snow detention is the most important means of improving soil climate. Where 30-50 centimeters of snow accumulate in the first half of winter, a peculiar soil climate is created which differs sharply from external or atmospheric climate, as well as from the soil climate where natural snow cover is slight or completely lacking. For example, when on 3 February 1943 the atmospheric temperature was 43.1 degrees below zero and the soil temperature at a depth of 3 centimeters in a spot without snow cover was 32.0 degrees below zero, the temperature of soil under 16 centimeters of snow was 20.8 degrees below zero and under 58 centimeters of snow only 8.0 degrees below zero. The temperatures of soils under accumulations of snow are quite uniform and definitely do not change according to extreme atmospheric temperature drops.

In spring, the snow melting process, which lasts 5 to 10 days, and sometimes even 12 days, mitigates the sharp variations in soil temperatures which occur in exposed soils, especially when spring comes early. The depth to which soil freezes is also reduced, a circumstance which hastens the thawing-out process in the spring and thereby reduces the quantity of snow water run-off. Thus, the soil receives a supplementary quantity of moisture.

For example, toward the end of 1943, a certain soil area was measured for moisture content. It was found that the moisture content in a layer one meter deep amounted to 115 millimeters. In the spring, places where no snow had accumulated showed a moisture content of 130 millimeters, whereas places which had been covered with accumulated snow contained 180 millimeters of moisture. Since rainfall in southwestern Siberia is irregular and the spring and early summer quite dry, the creation of a moisture reserve in the soil during the spring is very important for raising consistently good crops.

Analysis of weather data for Barnaul over a period of 100 years indicates that two thirds of all the snow falls during the first half of winter in the overwhelming majority of years, including winters when little snow falls. However, the snow cover does not become very deep during this period because strong winds drive it from the fields. The depth of the snow cover on the fields does not correspond with the measured fall. Calculations show that were it evenly distributed and blowing eliminated, it would be possible to attain snow cover 30-50 centimeters deep during the first half of winter and 50-80 centimeters deep during the second half. By adding snow from other fields, even deeper snow cover could be obtained.

The Barnaul and special experiments, as well as practical work by leading economists, have shown that snow cover of sufficient depth to improve soil climate can be created by applying agricultural engineering techniques for the retention and even distribution of snow. Finally, the light soil and the small amount of rainfall in the fall and spring are factors compelling effective use of snow accumulations to increase water reserves in the soil.

The first conclusion that may be drawn is that by using the free forces of nature (snow and wind) it is possible to replace a distinctly continental, very cold, dry, and heterogeneous soil climate in a region of small fields by a constant, homogeneous, moderately cold, and moister soil climate favorable for growing better and larger crops.

The second conclusion is that snow detention, organized and carried out according to plan over areas covering millions of hectares, while improving soil climate in many parts of Siberia and other regions of the USSR, undoubtedly will exert a positive influence and can result in decided changes in soil utilization processes, soil structure, and soil fertility. Attendant problems must be fully explored and studied by scientific work in the field of soil climatology, a very important, though new, division of Soviet soil science.

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